

The Lichen Genus *Pertusaria* in Rarotonga, Cook Islands

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Abstract

The first account of the lichen genus *Pertusaria* (Pertusariaceae) on the island of Rarotonga (Cook Islands) is given. A total of 8 taxa are recorded, of which 5 are new to science viz: *Pertusaria atroguttata*, *P. homilocarpa*, *P. megacarpa*, *P. rarotongensis* and *P. rarotongensis* var. *stictica*. A key to the species is provided.

Introduction

The Cook Islands are located between Tonga and the islands of French Polynesia in the South Pacific Ocean and consist of a group of 15 islands formed into a widely scattered northern group and a more compact southern group with a total land area of 237 square kilometres. The island of Rarotonga is in the southern group, at 21°12'–21°15'S, 159°44'–159°50'W, and with an area of 67.4 square kilometres is the largest of the islands. An introduction to the geology, landforms, vegetation and lichenological history of the island has been provided by McCarthy (2000). The climate is warm, humid tropical with an average humidity of 80–85%, an average annual rainfall of 2200 mm and with a winter temperature range of 20–26°C, rising to 24–30°C in the summer months.

This paper forms the fourth recent contribution on the lichens of Rarotonga following accounts of the pyrenocarpous lichens (McCarthy 2000), the Parmeliaceae (Louwhoff and Elix 2000) and *Ramalina* (Blanchon and de Lange 2011). The lichen genus *Pertusaria* has not previously been reported from the Cook Islands (Elix and McCarthy 1998).

Materials and methods

Specimens were collected on the island of Rarotonga in June 1998 and later examined using Olympus VMT and Olympus BHA microscopes. The chemistry of the species was studied by thin layer chromatography (Elix 2014) and comparison with authentic samples. Photographs of the specimens were taken with a Canon EOS camera fitted with a Canon MP 65mm f 2.8, 1–5x lens, at a magnification of x4.

New species

Pertusaria atroguttata A.W.Archer & Elix, *sp. nov.* Fig. 1

MB 810572

Diagnosis: Similar to *Pertusaria alboatra* Zahlbr. but differs in lacking thiophaninic acid and in having three ascospores per ascus.

Type: Cook Islands, Rarotonga: mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix* 42992, 9 Jun 1998; holotype: CANB.

Thallus off-white, epiphloedal, surface tuberculate, slightly cracked, subnitid, soredia and isidia absent; apothecia verruciform, conspicuous, concolorous with the thallus, hemispherical, sunken above, constricted at the base, 0.8–1.5 mm diam. ostioles black, conspicuous, 0.2–0.25 mm diam., 2–4 per verruca; ascospores 3 per ascus, ellipsoid, inner spore wall smooth, 90–120 µm long, 32–40 µm wide.

Chemistry: 2'-*O*-methylperlatolic acid (major), 2'-*O*-methylstenosporic acid (minor), planaic acid (minor), methyl 2'-*O*-methylperlatolate (minor) and methyl planaiate (minor).

Etymology: from the Latin *atro*, black and *guttatus*, spotted from *gutta*, a drop, or spot, a reference to the conspicuous black ostioles.

Substrate and ecology: It grows on the bark of *Hibiscus* in strand vegetation.

Discussion: *Pertusaria atroguttata* is characterised by the conspicuous black ostioles on white apothecia and the presence of 2'-*O*-methylperlatolic acid as a major lichen compound. This compound distinguishes the new species from the somewhat similar *P. alboatra* Zahlbr. (Zahlbruckner 1941) which only contains thiophaninic acid. *Pertusaria atroguttata* also resembles *P. melaleuroides* Müll. Arg. (Müller 1884) from New Zealand, as this species also has conspicuous black ostioles [cf. Fig.1 in Archer 1991, as *P. atropunctata*] but lacks lichen compounds. The recently described *Pertusaria parasommerfeltii* Q.Ren from China (Ren 2014) also resembles *P. atroguttata* [cf. Fig. 2 in Ren 2014] but that species has eight ascospores per ascus and contains 4,5-dichlorolichexanthone in addition to 2'-*O*-methylperlatolic acid.

At present this new species is only known from the type specimen.



Fig. 1. *Pertusaria atroguttata*, holotype. Scale: 1 mm

Pertusaria homilocarpa A.W.Archer & Elix, *sp. nov.* Fig. 2

MB 810573

Diagnosis: Similar to *Pertusaria pertusella* Müll. Arg. but with apothecial verrucae which are constricted at the base, and with smaller ascospores and darker ostioles.

Type: Cook Islands, Rarotonga: mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix 43007*, 9 Jun 1998; holotype: CANB.

Thallus pale greenish white, epiphloedal, surface smooth to subtuberculate, subnitid, slightly cracked, soredia and isidia absent; apothecia verruciform, concolourous with the thallus, numerous, crowded, sometimes confluent, flattened hemispherical, constricted at the base, 0.7–0.9 mm diam., confluent verrucae to 1.2 mm diam.; ostioles black, punctiform, 1–4 per verruca; ascospores 2 per ascus, fusiform-ellipsoid, inner spore wall smooth, 90–110 µm long, 28–32 µm wide.

Chemistry: 2,5-dichlorolichexanthone (minor), 2,4-dichlorolichexanthone (trace), 2,4,5-trichlorolichexanthone (minor), stictic acid (major), constictic acid (minor) and cryptostictic acid (trace).

Etymology: From the Greek, *homilos*, a crowd or throng, and *carpus*, fruit, a reference to the crowded apothecia.

Substrate and ecology: It grows on the bark of *Hibiscus* in strand vegetation.

Discussion: *Pertusaria homilocarpa* is characterised by asci with two ascospores and the presence of 2,5-dichlorolichexanthone, 2,4-dichlorolichexanthone, 2,4,5-trichloro-lichexanthone and stictic acid. This combination of characters is also present in *P. pertusella* Müll. Arg. (Müller 1884; Archer 1997) and *P. nigrescens* Srivastava & Awasthi (Awasthi & Srivastava 1993), but in these two species the apothecial verrucae are not constricted at the base as is *P. homilocarpa*. The ostioles in *P. homilocarpa* are black and punctiform in contrast to the ostioles present in *P. pertusella* which are pale to dark brown and these two species are further differentiated by the size of the ascospores, 90–110 µm long in *P. homilocarpa* and 100–140(–160) µm long in *P. pertusella*.

At present this new species is only known from the type specimen.



Fig 2. *Pertusaria homilocarpa*, holotype. Scale: 1 mm

Pertusaria megacarpa A.W.Archer & Elix, *sp. nov.* Fig. 3

MB 810574

Diagnosis: similar to *Pertusaria parnassia* Vain. but lacking lichexanthone and stictic acid.

Type: Cook Islands, Rarotonga: mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix* 42998, 9 Jun 1998; holotype: CANB.

Thallus pale olive green, surface subtuberculate, subnitid, rarely cracked, margin entire and not zoned; soralia and isidia absent. Apothecia verruciform, conspicuous, scattered or sometimes confluent, flattened hemispherical, concolourous with the thallus, 1–1.8 mm diam. Ostioles conspicuous, pale, translucent, one per verruca, sunken, 0.2–0.3 mm diam. Ascospores 8 per ascus, 2-seriate, initially ellipsoid, becoming fusiform-ellipsoid, inner spore wall rough, 120–150 µm long, 34–42 µm wide.

Chemistry: no lichen substances detected.

Etymology: from the Greek *mega*, large and *carpus*, fruit, a reference to the large apothecia.

Substrate and ecology: It grows on the bark of *Hibiscus* in strand vegetation.

Comments: The new species is characterised by the large apothecia, the eight rough-walled ascospores per ascus and the absence of lichen compounds. This latter feature distinguishes the new species from *P. parnassia* Vain., described from Guadaloupe (Vainio 1899), as this contains lichexanthone and stictic acid and has eight ascospores with rough inner walls. In addition the ostioles in *P. parnassia* are black and punctiform, quite distinct from the large translucent ostioles present in *P. megacarpa*.

Pertusaria species with eight rough-walled ascospores are rare and only two other such species are known viz: *P. anomalospora* A.W.Archer, Elix & Streimann (Archer *et al.* 1995), described from Papua New Guinea and which contains isomeric dichlorolichexanthenes and has ascospores 105–135 µm long, and *P. lambinonii* A.W. Archer, Elix, Eb. Fisch. Killmann & Sérus. (Archer *et al.* 2009), described from Central Africa, which contains lichexanthone, planaic acid, 2'-O-methylperlatolic acid and protocetraric acid, and has ascospores 80–125 µm long.

Additional specimen examined: Cook Islands, Rarotonga: mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix* 42985, 9 Jun 1998; (CANB).



Fig. 3. *Pertusaria megacarpa*, holotype. Scale: 1 mm

Pertusaria rarotongensis A.W.Archer & Elix, *sp. nov.* Fig. 4

MB 810575

Diagnosis: similar to *Pertusaria bogia* A.W.Archer & Elix but differs in lacking stictic acid and in having ascospores with a rough inner wall.

Type: Cook Islands, Rarotonga: mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix* 42986, 9 Jun 1998; holotype: CANB.

Thallus pale olive green, epiphloedal, margin entire and not zoned; surface subtuberculate, slightly cracked, subnitid, soredia and isidia absent; apothecia verruciform, concolourous with the thallus, hemispherical 0.4–0.5 mm diam., the majority becoming confluent to form irregular, flattened apothecia, approximately 2–3.5 mm long and 1–2 mm wide; ostioles black, punctiform, 1 per verruca but up to 18 in confluent verrucae. Ascospores 3(or 4) per ascus, ellipsoid, the inner spore wall slightly roughened, 74–100 µm long and 34–40 µm wide.

Chemistry: 4,5-dichlorolichexanthone (minor), 2'-*O*-methylconfluentic acid (major) and confluentic acid (trace).

Etymology: from Rarotonga and *ensis*, place of origin.

Substrate and ecology: It grows on the bark of *Hibiscus* in strand vegetation.

Comments: *Pertusaria rarotongensis* is characterised by the multi-ostiolate, flattened apothecia and the presence of 2-*O*-methylconfluentic acid and is similar to *P. bogia* A.W.Archer & Elix described from Papua New Guinea (Archer & Elix 1998). However, the new species is differentiated from *P. bogia* by the absence of stictic acid (present in *P. bogia*) and the rough walled ascospores (smooth walled in *P. bogia*).

Table 1. Comparisons of *Pertusaria bogia*, *P. rarotongensis* var. *rarotongensis* and *P. rarotongensis* var. *stictica*.
Legend: – = absent; + = present

Taxon	spore length (µm)	inner spore wall	stictic acid
<i>P. bogia</i>	85–125	smooth	–
<i>P. rarotongensis</i> var. <i>rarotongensis</i>	74–100	rough	–
<i>P. rarotongensis</i> var. <i>stictica</i>	105–130	rough	+



Fig. 4. *Pertusaria rarotongensis*, holotype. Scale: 1 mm

2'-O-Methylconfluent acid is an uncommon lichen compound in *Pertusaria* and is presently known from only five taxa. Two species containing 2'-O-methylconfluent acid are known from North America, the corticolous, two-spored *P. saximontana* Wetmore and the saxicolous, four-spored *P. arizonica* Dibben (Dibben 1980). In addition there is the isidiate, sterile *P. georgeana* var. *occidentalis* Elix & A.W.Archer from Western Australia (Archer & Elix 2009) and *P. bogia* A.W.Archer & Elix, from Papua New Guinea but these two species are morphologically distinct from *P. rarotongensis*. A similar taxon, but with additional stictic acid is described as *Pertusaria rarotongensis* var. *stictica* below; the differences between *P. bogia*, *P. rarotongensis* var. *rarotongensis* and *P. rarotongensis* var. *stictica* are shown in Table 1.

At present this new species is only known from the type specimen.

Pertusaria rarotongensis* var. *stictica A.W.Archer & Elix, var. nov. Fig. 5

MB 810576

Diagnosis: similar to *Pertusaria rarotongensis* (*vide supra*) but containing additional stictic acid.

Type: Cook Islands, Rarotonga, Taputarangi Track, 21°12'S, 159°48'W, alt. 100 m, on fallen tree in relatively open tropical forest, J.A.Elix 42748, 6 Jun 1998; holotype: CANB.

Thallus pale olive green, epiphloedal, margin entire and not zoned; surface smooth, slightly cracked, subnitid, soredia and isidia absent; apothecia verruciform, concolourous with the thallus, hemispherical, constricted at the base, often confluent; individual apothecia 0.6–1.0 mm diam. but confluent apothecia flattened, 2.5–4 mm long and 1–2 mm wide; ostioles black, punctiform surrounded by a pale grey, translucent zone, 1 or 2 in individual verruca but 7–18 in confluent verrucae. Ascospores narrow ellipsoid, inner spore wall rough, 3(or 4) per ascus, 105–130 mm long, 30–43 mm wide.

Chemistry: 4,5-dichlorolichexanthone (minor), stictic acid (major), constictic acid (minor), cryptostictic acid (trace) and 2'-O-methylconfluent acid (major)

Etymology: Like *P. rarotongensis* but containing additional stictic acid.

Substrate and ecology: on the bark of a fallen tree in relatively open tropical forest.

Comments: The new variety resembles *P. rarotongensis* but contains additional stictic acid. At present this new species is only known from the type specimen.



Fig. 5 *Pertusaria rarotongensis* var. *stictica*. Scale: 1 mm

New Reports

Pertusaria commutata Müll.Arg. *Flora* 67: 269 (1884)

Pertusaria commutata Müll.Arg. is characterised by disciform apothecia with one ascospore per ascus and the presence of haemathamnolic acid.

Specimen examined: Cook Islands, Rarotonga: Te Kou Track, lower level, 21°13'S, 159°46'W, alt. 80 m, on *Cecropia* branch in scattered regrowth forest and taro gardens, *J.A.Elix* 42853, 7 Jun 1998 (CANB).

Pertusaria montpittensis A.W.Archer in J.A.Elix, H.Streimann & A.W.Archer, *Proceedings of the Linnean Society of New South Wales* 113: 65 (1992)

Pertusaria montpittensis A.W.Archer is characterised by an isidiate thallus lacking apothecia and containing 4,5-dichlorolichexanthone and stictic acid. It grows on both corticolous and saxicolous substrata.

Specimens examined: Cook Islands, Rarotonga: Avana Stream, 400 m E of water tanks, 21°14'S, 159°45'W, alt. 60 m, on *Hibiscus* in moist, lowland tropical forest, *J.A. Elix* 42802, 6 Jun 1998 (CANB); Te Kou Track, lower level, 21°13'S, 159°46'W, alt. 80 m, on basalt/breccia rocks in scattered regrowth forest and taro gardens with rock outcrops, *J.A. Elix* 42828, 7 Jun 1998 (CANB); *J.A.Elix* 42829 (CANB); Raemaru Track, upper level, 21°14'S, 159°49'W, alt. 200 m, on treelet in fern dominated slopes with scattered *Albizzia*, *J.A. Elix* 42904, 8 Jun 1998 (CANB); mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix* 42999, 9 Jun 1998 (CANB)

Pertusaria thiospoda C.Knight *Transactions of the Linnean Society of London, Botany* 2: 47 (1882)

Pertusaria thiospoda C.Knight is characterised by verruciform apothecia with two ascospores per ascus and the presence of thiophaninic and stictic acids.

Specimen examined: Cook Islands, Rarotonga: mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A.Elix* 43002, 9 Jun 1998 (CANB).

Varicellaria velata (Turner) Schmitt & Lumbsch *Mycoskeys* 4: 31 (2012)

Pertusaria velata (Turner) Nyl. *Lich. Scand.* (Uppsala): 179 (1861)

Parmelia velata Turner *Transactions of the Linnean Society of London* 9: 143 (1808)

Varicellaria velata is characterised by disciform apothecia with one ascospore per ascus and the presence of lecanoric acid. The species was recently transferred from *Pertusaria* to *Varicellaria* (Schmitt *et al.* 2012) and is therefore not included in the Key below.

Specimens examined: Cook Islands, Rarotonga: Avana Stream, 400 m E of water tanks, 21°14'S, 159°45'W, alt. 60 m, on *Hibiscus* in moist, lowland tropical forest, *J.A. Elix* 42794, 6 Jun 1998 (CANB) ; mouth of Avana Stream, 21°14'S, 159°43'W, alt. 1 m, on *Hibiscus* in strand vegetation, *J.A. Elix* 42993, 9 Jun 1998 (CANB).

Key to the genus *Pertusaria* in Rarotonga

- 1 Apothecia lacking, with isidia *P. montpittensis*
- 1: Apothecia verruciform or disciform 2
- 2 Thallus with disciform apothecia; thallus K+yellow, C-ve; haemathamnolic acid present *P. commutata*
- 2: Thallus with verruciform apothecia 3
- 3 Ascospores with rough inner wall 4
- 3: Ascospores with smooth inner wall 6
- 4 Ascospores 8 per ascus, 120–150 µm long; lichen compounds absent *P. megacarapa*
- 4: Ascospores 3 or 4 per ascus, 74–130 µm long; 2'-O-methylconfluentenic acid present 5
- 5 Stictic acid present *P. rarotongensis* var. *stictica*
- 5: Stictic acid absent *P. rarotongensis* var. *rarotongensis*
- 6 Ascospores 2 per ascus; ostioles not black and conspicuous 7
- 6: Ascospores 3-4 per ascus; ostioles black, conspicuous *P. atroguttata*
- 7 Ostioles pale yellow; thiophaninic acid present *P. thiospoda*
- 7: Ostioles black, punctiform; thiophaninic acid absent *P. homilocarpa*

Conclusion

The genus *Pertusaria* exhibits a high degree of endemism throughout its distribution. Approximately 45% of Australian taxa are endemic (Archer 2004), 50% of New Zealand (Galloway 2007) and total North American species (Dibben 1980), while in temperate North America approximately 75% are endemic to the continent. Given this background, the fact that 5 of the 8 taxa recorded for Rarotonga are endemic is not as surprising as it initially appears.

Acknowledgments

We thank Gerald McCormack from the Cook Island National Heritage Project for his support and advice, Patrick McCarthy and Simone Louwhoff for accompanying JAE in the field and the Australian Research Council for generous financial assistance.

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